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REPORT

Background Document on the Basis of Revised Exemption Quantities

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Canada

Background Document on the Basis of Revised Exemption Quantities

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Executive Summary

Exemption Quantities (EQ's) have been modified because of new regulatory dose limits and the publication by the International Commission on Radiological Protection of new dose conversion factors for inhalation (ICRP Publication 68)[1]. The new EQ's are presented in Table 1, at the end of this document, and the models and parameters used in the derivation of EQ's are presented in the appendices. The parameters selected for the various models are generally conservative and were chosen to ensure that it is highly unlikely that any individual would exceed any of the dose criteria presented in this document.

Sommaire

Les Quantités d'exemption ont été modifiés suite aux nouvelles limites de dose et à la publication de nouveaux facteurs de conversion de dose par la Commission internationale de protection radiologique (Publication No. 68 de la CIPR)[1]. Les nouvelles quantités d'exemption sont présentés au tableau 1, à la fin de ce document. Les modèles et paramètres ayant servi à dériver ces quantités d'exemption se retrouvent en annexe. Des valeurs de paramètres prudentes ont été choisies afin qu'il soit très peu probable de dépasser n'importe lesquels des critères de dose utilisés dans ce document.

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Purpose

The purpose of this document is to present and briefly discuss the results of the review, to present criteria on which new exemption quantities for each radioactive prescribed substance are based, and to describe the models used to derive exemption quantities compatible with these criteria.

1. Introduction

The AECB proposes to issue new regulations dealing with radiation protection. The new regulations will incorporate a number of changes from the current AEC Regulations. Under those regulations, Scheduled Quantities were used to determine whether a practice was licensable under the AECB's regulatory process. Possession of no more than one Scheduled Quantity exempted a practice from regulatory control.

In the new regulations, significant changes have been made to the dose limits for workers and for the public, as recommended in recent publications of the ICRP; for example ICRP - 60[2]. New values are also needed to replace the old Scheduled Quantities. They were also given a new name, Exemption Quantities. In order to derive the new values, the bases for calculating them were reviewed to ensure that the most appropriate criteria, including exposure pathways, are employed.

1.1 Review of the Bases for the Present Scheduled Quantities

The Scheduled Quantities currently contained in Schedule 1, Part 1 of the Atomic Energy Control Regulations are based on the "exempt quantities" contained in IAEA Safety Series No. 9 (Basic Safety Standards for Radiation Protection)[3], published in 1967. As contained in IAEA Safety Series No. 9, exempt quantities for radioactive substances are based on one tenth of the most restrictive Maximum Permissible Annual Intake (MPAI) for that substance, which is defined as:

> "that quantity of a radioactive substance which if inhaled or ingested each year for fifty years would result in an annual dose rate to the whole body, or individual organ or tissue equal to the appropriate regulatory dose limit for workers, at equilibrium or during the fiftieth year of intake."

In deriving the exempt quantity, the IAEA placed a lower limit of 0.1 μCi (3700 Bq) and a maximum limit of 100 μCi (3.7 MBq) on the selected value, after rounding one tenth of the MPAI to the nearest value of 0.1, 1, 10 or 100 μCi. The exempt quantity for tritium, 1000 μCi (37 MBq), was the one exception to the rule.

Limitation of doses received by members of the public, at one tenth the dose to workers, was to be achieved by control over the quantity of radioactive substances possessed, rather than over the use of the material. Possession of up to one scheduled quantity would not result in a dose to any individual exceeding a dose limit applicable to a member of the public and would not, therefore, require licensing under the scheme recommended by the IAEA.

Doses potentially received by individuals from radioactive substances external to the body, which was governed by use of the material, were to be controlled by limiting measured dose rates, and not the quantity of radioactive substance possessed.

The dose limits on which the IAEA MPAI values were based are identical to those contained in the present AEC Regulations, and the present Scheduled Quantities were, with a few exceptions, adopted from exempt quantities contained in Table II A of IAEA Safety Series No. 9. Although a few scheduled quantities differ from the corresponding exempt quantities contained in the IAEA document, the exceptions do not differ by more than a factor of ten.

The ICRP has used the term Annual Limit on Intake (ALI), whose definition follows:

> "The activity of a radionuclide which taken alone would irradiate a person, represented by Reference Man, to the limit set by the ICRP for each year of occupational exposure."

1.2 Present Uses of Scheduled Quantities

The Scheduled Quantities listed in the old regulations are used for the following purposes:

1.2.1 exemption from the requirement to obtain from the AECB a licence to possess a substance if the concentration of radioactive isotopes of elements of atomic number less than 90 is less than one scheduled quantity per kilogram of material or less than one-tenth of a scheduled quantity per square metre;

1.2.2 exemption from licensing requirements for sources of ionizing radiation containing radioactive isotopes of atomic number less than 90 if each source possessed does not contain more than one scheduled quantity, and if not more than ten scheduled quantities are required per year;

1.2.3 exemption from licensing requirements for any single device incorporating up to ten scheduled quantities of radioactive prescribed substances of atomic number less than 90, or of Americium 241, and if the device is approved by the AECB;

1.2.4 rooms containing more than 100 scheduled quantities are required, by regulation, to have appropriate signs;

1.2.5 the complexity of radiation protection programmes required under the terms of a radioisotope licence issued by the AECB is determined by the number of scheduled quantities possessed.

2. Criteria and Models for Calculating Exemption Quantities

2.1 Revised Criteria for Determining Exemption Quantities

The following criteria were employed in deriving exemption quantities:

A. The possession and use of one exemption quantity must not result in an annual or committed effective dose in excess of 1 mSv from exposure to photon sources external to the body or intake of radionuclides respectively;

B. The possession and use of one exemption quantity must not result in an annual dose to any portion of the skin in excess of 50 mSv; and

C. The possession and use of one exemption quantity must not result in an annual dose to the lens of the eye in excess of 15 mSv.

2.2. Models for Calculating Exemption Quantities

In order to calculate an exemption quantity, a number of exposure scenarios and related models were employed. These scenarios are introduced briefly here, while details of the models used for each scenario are discussed in individual appendices to this document.

The following exposure scenarios or pathways were considered:

a) the inhalation of possessed radionuclides;

b) whole-body and localized skin irradiation arising from photon sources located in a front trouser pocket of an individual;

c) irradiation of the skin of the fingers and hands arising from the handling of radionuclides;

Although absorption of a radionuclide through intact skin is possible, this exposure scenario is, with the exception of tritiated water (HTO), of only minor significance. Absorption through the skin was considered only for HTO.

Quantities calculated for each of the above exposure scenarios, and in accord with the dose limitation criteria, are termed Derived Possession Limits in this document. The most restrictive of the derived possession limits for each radionuclide is proposed as the exemption quantity.

3. Exemption Quantities

Table 1 contains Derived Possession Limits and proposed Exemption Quantities for 115 radionuclides. For each nuclide, limits are calculated by using one or all of the applicable

models. The largest of the values obtained in each case is underlined in the table; the exemption quantity is a rounded approximation in each case.

Schedule 1 of the current Regulations also contains two "default" values to be used for radionuclides not specifically contained in the list of scheduled quantities. These values are 0.1 μCi (3.7 kBq) for isotopes of atomic number greater than 89, and 1 μCi (37 kBq) for isotopes of atomic number equal to or less than 89.

The proposed "default" values are:

(I) 10^4 (1 E+04) Bq, where the atomic number of the radioactive isotope is equal to or less than 81; or

(ii) 10^4 (1 E+04) Bq, where the atomic number of the radioactive isotope is greater than 81, and where the radioactive isotope or its short-lived radioactive progeny do not emit alpha particles;

(iii) 100 (1 E+02) Bq, where the atomic number of the radioactive isotope is greater than 81, and where the radioactive isotope or its short-lived radioactive progeny emit alpha particles.

The value of 10^4 Bq is recommended on the basis that, with only a few exceptions, it is the lowest value of any exemption quantity in Table 1 for isotopes of elements of atomic number equal to or less than 81. The atomic number 81 was chosen because no radionuclides of atomic number 81 or less are alpha emitters.

The most restrictive exemption quantity contained in Table 1 for alpha-emitting isotopes of elements of atomic number greater than 81 is 100 Bq, and this has been selected as the default exemption quantity for such isotopes of elements of atomic number greater than 81.

Appendix 1

MODEL 1

Internal Dose

Model 1: Internal Dose Model

The two major pathways by which radionuclides may be taken into the body are inhalation and ingestion. Although the probability of an individual ingesting a derived possession limit is not zero, it is much less than one, and the ingestion pathway has, therefore, been ignored.

Simple models have been derived for calculating the fraction which may be inhaled from an available quantity of a radionuclide. These are described in Appendix 2. Some radionuclides have relatively low specific activities, and it is unreasonable to assume that one ALI would be inhaled. For example, one ALI for inhalation of pure K-40 is 6 MBq or 15.6 g. Canadian experience in uranium refineries and fuel fabrication plants has shown that even when kilogram quantities of material are handled per year, only a few tens of milligrams of material are inhaled annually. Accordingly, consideration was given to the mass of material associated with the ALI (inhalation) for radionuclides of low specific activity, and when one ALI (inhalation) equalled or exceeded 100 milligrams, the inhalation pathway was not further considered for the calculation of derived possession limits.

The simple models used in Appendix 2 for calculating the fractions of available radionuclides which may be inhaled assumed that all of the material became airborne, either instantaneously or over a prolonged period of time. Such an assumption is likely to be valid only if the radionuclide is in a volatile form, is composed of very fine particles (< 10 μm) not chemically or physically bound to a surface.

Appendix 2

Models for the Estimation of the Percentage of a Radioactive Prescribed Substance Which May Be Inhaled

Model I: Chronic Exposure (Inhalation)

A quantity of radioactive prescribed substance, A Bq, is assumed to become airborne at a constant rate for a period of eight hours into a 100 m^3 room, with 6 air changes per hour (from DiBerardinis, *et al*, "Guidelines for Laboratory Design")[4].

At equilibrium conditions, the concentration of an airborne radionuclide under the above conditions is:

$$C = \left(\frac{1}{\lambda_{AC}}\right)\left(\frac{A}{T}\right)\left(\frac{1}{V}\right)$$

C = equilibrium concentration, in Bq/m^3
λ_{AC} = number of air changes per hour in the room, in hr^{-1}
A = Activity becoming airborne, in Bq
T = duration of release of activity A, in hours.
V = room volume, in m^3

Using the assumptions in the first paragraph, this equation can be expressed as:

C (equilibrium) = $(1/6)(A/8)(1/100) = (A/4800) = 2 \times 10^{-4}$ A Bq/m^3

For an eight hour exposure time and a breathing rate[5] of 1.2 m^3/hr, each individual within the room would have inhaled about 0.02% of the radionuclides dispersed into the room.

Model II: Acute Exposure (Inhalation)

The assumptions used in this model are as follows:

a) The radioactive substance (A Bq) is released instantaneously into 1 m^3 of air near an individual;

b) The radioactive substance contained in the 1 m^3 of air is not immediately dispersed in room air and takes one minute to pass through the breathing zone of an exposed individual; and

c) The exposed individual inhales air at the rate of 20 l/min (Reference Man)[5].

The intake of radioactive substance during the passage of the 1 m^3 "slug" of contaminated air represents an exposure to A Bq/m^3 for a period of 1 minute. The total intake during this exposure time of 1 minute, assuming a breathing rate of 20 litres (0.02 m^3) per minute, is:

$$\left(A \frac{Bq}{m^3}\right)(1 \text{ min})\left(0.02 \frac{m^3}{\text{min}}\right)$$

The total intake during the exposure time of 1 minute is therefore 0.02A Bq or 2% of the possessed material. In addition to the chronic intake of 0.02 % A, an additional intake of 2% of the material dispersed in room air will occur, for a total intake of 2.02 %.

Comparison of Recommended Intake Fraction with Other Guidelines

The intake fraction recommended here can be compared to that in other guidelines. NUREG-1400[6] recommends the following potential intake fraction (PIF).

$$PIF = 10^{6} \times R \times C \times D \times O$$

Where:
R = Release factor
C = Confinement factor
D = Dispersibility factor
O = Occupancy factor
10^{-6} = Brodsky's factor[7]

A conservative scenario could have the following values associated with each of the parameters[6].

R = 1 (gases, strongly volatile liquids)
C = 100 (open bench-top or surface contamination in a room with normal ventilation)
D = 1 (no energy added to the system)
O = 250 (essentially daily contact)

Such a scenario would lead to a potential intake fraction of:

$PIF = 10^{-6} \times 1 \times 100 \times 1 \times 250$

$PIF = 0.025$

PIF = 2.5 %

It can be seen that this value is similar to that recommended in this appendix.

Model for Calculating Derived Possession Limits

Since the intake of one ALI will result in a committed effective dose of 20 mSv, the criterion of a committed effective dose of 1 mSv as the result of inhalation may be achieved by limiting the possession of a radioactive prescribed quantity to 1/20th of an ALI. In practice, however, the criterion may be met by limiting possession to (0.05/0.0202)ALIs, or 2.5 ALIs based on the above calculations.

Appendix 3

MODEL 2

External Exposure of the Whole Body and Skin from Photon Sources

EXTERNAL EXPOSURE OF THE WHOLE BODY AND SKIN BY PHOTONS

The possession or use of unshielded radionuclides which emit gamma or X-rays could result in the receipt by exposed individuals of localized skin and effective doses. Limitations on the quantities possessed are intended to ensure that the annual effective and localized skin doses do not exceed 1 or 50 mSv, respectively. The following exposure scenarios are considered:

1. irradiation by a photon-emitting source contained in the front trouser pocket of an individual;

2. irradiation by a source handled at waist height and a distance of 0.33 metre from the front surface of an individual; and

3. as in 2 above, but at a distance of 1 metre.

The radioactive sources are assumed to be circular with a surface area of one cm^2, such that source construction or other shielding does not significantly reduce the number of photons emitted from the surface.

The derivation of dose rate conversion factors as a function of photon energy for each of the exposure scenarios considered above, and for combinations of exposure time and source distance, is discussed in sections a) and b) below, while the final selection of an exposure scenario is contained in section c).

a) Dose Rate Conversion Factors

In order to calculate the effective dose rate, as a function of photon energy, received from a photon emitter located in the front trouser pocket of an individual, the source is assumed to be located in the testes and the following procedures used. This assumption was made because the best available dose rate data for irradiation of organs by a source in the front trouser pocket area was for a source in the testes (ICRP 23). Because of the pocket geometry assumed, the dose to testes is significantly greater than to the ovaries in a woman.

1) data from the "Source in Testes" section of Table I.2 in ICRP-23 were used to calculate weighted dose rates received by each significantly irradiated organ or tissue and the results summed. The doses received by the testes and breast themselves were not included;

2) weighted dose rates received by the testes and breast were calculated by assuming that the source was located at distances of 0.1 and 0.3 metre from the testes and breast, respectively; and

3) the results of the calculations of the two forgoing procedures were summed to obtain the effective dose rate as a function of photon energy.

A comparison of the effective dose rate conversion factors derived for photon sources located at distances of 0.33 or 1 metre reveals that the effective dose rates are about 0.25 and 0.025, respectively, of those received from a photon source located in the front trouser pocket.

b) Exposure Time - Source Location Combinations

A variety of realistic combinations of exposure times and distances are possible when solid photon emitting sources are possessed by individuals.

The following examples result in identical annual effective dose rates, over the period of one calendar year, for radionuclides with half-lives in excess of a few hundred days.

Table A

Source Exposure Combination	Source Exposure Location 1		Time 1	Location 2		Time 2
1.	Pocket	for	20 hr	-		-
2.	0.33 m	for	80 hr	-		-
3.	1 m	for	80 hr	-		-
4.	0.33 m	for	50 hr	Pocket	for	7.5 hr
5.	0.33 m	for	30 hr	Pocket	for	12.5 hr
6	0.33 m	for	20 hr	Pocket	for	15 hr

c) Selection of Derived Possession Limits Based on External Photon Irradiation

Localized photon doses are considered only for examples 1, 2, 3, and 4 in Table A above. Since the dose rate conversion factors for irradiation of localized areas of the skin are about 2000 times those for effective dose rates, only those examples which assume that a radioactive source is in a pocket were considered further in the selection of a derived possession limit.

Appendix 4

MODEL 3

Irradiation of the Skin of the Fingers and Hands

EXTERNAL IRRADIATION OF THE SKIN OF THE HANDS

The handling of radionuclides which undergo nuclear transformations resulting in the emission of energetic electrons, beta particles, or photons (X and gamma-rays) may result in localized equivalent doses to the skin of the fingers or the hands in excess of 50 mSv annually.

The following assumptions are made for the purposes of calculating exemption quantities based on the potential for irradiation of the skin or the hands:

a) radionuclides are deposited on the surface of a disc such that there is insignificant attenuation of beta particles e. itted from the surface. Alternatively, the radionuclides may be present on the surface of th. kin as contamination.

b) the radionuclides are uniformly distributed over 1 cm^2 surface area;

c) radioactive progeny with half-lives of less than one year are likely to be present in significant quantities and are assumed to be in equilibrium with the parent radionuclides, while those with half-lives greater than one year are considered separately;

d) the basal cell layer of the skin is the tissue at risk and is at a depth of 0.4 mm (40 mg/cm^2) for the skin of the finger tips and palms of the hand; and

e) the discs are manipulated such that the skin of the fingers or palms of the hand is in contact with the radionuclide deposited on the disc for 3.04 hours per year (0.5 minutes per day, 250 days per year).

The area of 1 cm^2, over which the radionuclide is deposited on the disc (assumption b) was assumed because many radioactive sources used for calibration purposes are about this size. Additionally, the beta dose rate from an area source with a surface area of 1 cm^2 is the same as that from a "point" source of identical total disintegration rate, averaged over an area of 1 cm^2 at the depth of the basal layer.

Dose rate conversion factors (Sv/hr per Bq/cm^2) as a function of maximum (end point) beta-ray energy were derived from data contained in AECL-7617 (Tables of Beta-Ray Dose Distributions in Water, Air and other Media)[8]. Only those beta-rays and electrons with end-point energies in excess of 200 keV are considered, since beta-rays with energies less than this have insufficient range to reach the basal layer of the skin of the hands.

The dose from photons was added to that received from electrons and beta particles.

The basis for the Exemption Quantity for uranium is different from that of other radionuclides. Some uranium compounds are in dispersible form. The limiting model for these compounds is inhalation. The EQ for dispersible uranium compounds is 5000 Bq, based on the inhalation model in appendix 2.

It would be impractical, however, to impose an EQ of 5000 Bq for non-dispersible compounds of uranium. For this reason, an EQ for non-dispersible uranium compounds has been developed. In an attempt to propose an exemption quantity for natural uranium in ore, two main scenarios

were examined:

(I) an ore sample positioned 1 m away from a person for 2000 hours per year, e.g., ore sample on a person's desk or work bench;

(ii) an ore sample in contact with a person's hand (palm) for about 4.2 hours per year, i.e., 1 minute per day, 5 days per week, 50 weeks per year.

A 10 kg ore sample was considered as an appropriate mass for the above scenarios - reasonable for (I) and an upper limit for (ii). Several cases were examined in which the ore grade was varied from 5% to 40% resulting in increasing ore sample densities and decreasing sample volume. Of the cases examined, the one involving 5% ore was felt to be the most suitable. The calculations were based on the following assumptions:

Ore grade:	5% uranium by weight
Shape of ore sample:	Sphere
Density of ore sample:	3 g cm^{-3}
Exposure geometry:	Person located 1 m away from surface of the ore sample such that the whole body is irradiated (see (I) above)
	The palm of a person's hand is in contact with ore sample such that the skin of hand is irradiated (see (ii) above)
Secular equilibrium:	^{238}U is assumed to be in secular equilibrium with all of its progeny

Using the code MicroShield version 5.01[9], in combination with (I) and (ii) above, the following annual dose rates were obtained:

scenario 1: effective dose rate = 1.52 mSv/a

scenario 2: equivalent dose to the skin of the hand = 1.13 mSv/a

Since, for members of the public, the effective dose limit is 1 mSv/a and the skin dose limit is 50 mSv/a, scenario 1 is clearly more restrictive.

The effective dose rate of 1.52 mSv a^{-1} is an overestimate for the following reasons:

(I) Between 4% and 20% of radon progeny that is produced in Canadian ore escapes from the sample, depending on the porosity of the ore. This reduces the annual effective dose rate to somewhere in the range 1.22 mSv a^{-1} to 1.46 mSv a^{-1}; and

(ii) A person at a work station, i.e., desk, bench, etc., is not likely to be uniformly irradiated. In fact, by studying the exposure geometry, it would seem more likely that about 60% to 80% of a person's body would be exposed, the lower value being more likely. This results

in an annual effective dose rate range of 0.73 mSv a^{-1} to 1.16 mSv a^{-1}.

Accounting for a person's occasional absence from the work station, it is expected that in this scenario, the 1 mSv effective dose limit would be respected.

A 10 kg mass of 5% ore contains 500 g of uranium. This is equivalent to an activity of about 6 MBq. Therefore, it is recommended that the exemption quantity for non-dispersible uranium in ore be 6 MBq.

Appendix 5

MODEL 4

Immersion in a Cloud of

Radioactive Noble Gases

IMMERSION IN A RADIOACTIVE CLOUD

The possession or use of radioactive noble gases may result in annual effective doses or skin absorbed doses in excess of 1 mSv and 50 mSv, respectively, if such radionuclides become airborne and an individual is immersed in the resultant "cloud". Derived possession limits derived from consideration of annual effective doses or skin absorbed doses in relation to Criteria A and B, respectively, from immersion in clouds of radioactive noble gases were calculated on the basis of the following assumptions:

a) the airborne radioactive noble gases or volatile radionuclide are contained in a room of 100 m^3;

b) the room is approximated by a sphere with a radius of 2.9 meters;

c) an individual is located in the center of the room;

d) the air exchange rate in the room is 0.5 per hour;

e) all of the radioactive noble gas radionuclides possessed are released into the room either instantaneously or uniformly during a time period of eight hours, once per year; and

f) short-lived radionuclides of the parent are assumed to be in equilibrium.

Average concentrations of radioactive noble gases in the assumed room of 100 m^3 may be calculated from the following formula:

$$C = \frac{1}{(0.5 + D)} \left(\frac{1}{8}\right) \left(\frac{1}{100}\right) A \qquad Bq/m^3 \qquad where$$

C = the average or equilibrium concentration of radioactive noble gas in the room;
0.5 = the air exchange rate in the room, 0.5 per hour;
D = the decay constant of the radionuclide;
1/8 = the release rate of the radioactive noble gas into the room, per hour;
100 = the volume of the room, m^3 ; and
A = the quantity of radioactive noble gas initially contained in the room, Bq.

Comparison of the dose rate conversions for skin and for the lens of the eye indicates that the latter values are always less than 10% of the values for the skin for beta ray energies of less than about 2 MeV, and less than about 50% for energies of about 3 MeV. Beta rays with energies above 2 MeV are emitted by only a few radionuclides of interest for the immersion model, and such betas are emitted in relatively low abundance. Accordingly, the selection of an Exemption Quantity based on limiting the tissue dose to the skin of the whole body from Immersion in a radioactive cloud will ensure that the annual tissue dose to the lens of the eye will not exceed 15 mSv.

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Table 1 Derived Possession Limits and Exemption Quantities

Radionuclide	MODEL				Exemption Quantity
	Source in Pocket		Beta Dose to Skin of Hands	Internal Dose (Inhalation)*	
	Effective Dose (1 mSv Effective Dose)	Local Skin Dose (Gamma) 50 mSv Skin Dose (40 mg/cm2)	50 mSv Skin Dose (40 mg/cm2)		
	Becquerel	Becquerel	Becquerel	Becquerel	**Becquerel**
Am-241	5.2E+08	7.7E+05	7.7E+06	7E+02	**1E+03**
Am-243	9.1E+07	4.2E+05	7.5E+04	7E+02	**1E+03**
Sb124	1.7E+07	2.5E+05	2.7E+04	7E+06	**1E+04**
Sb-125	6.0E+07	4.3E+05	1.8E+05	1E+07	**1E+05**
As-73	2.8E+09	2.9E+05	2.7E+06	5E+07	**1E+05**
As-74	4.4E+07	3.6E+05	3.1E+04	2E+07	**1E+04**
As-76	3.5E+08	3.8E+06	1.4E+04	2E+07	**1E+04**
Ba-131	6.3E+07	4.1E+05	5.8E+05	2E+08	**1E+05**
Ba-133	6.1E+07	4.3E+05	4.6E+05	2E+07	**1E+05**
Ba-140	1.4E+07	2.2E+05	1.0E+04	2E+07	**1E+04**
Be-7	6.1E+08	4.9E+06	4.6E+07	7E+08	**1E+06**
Bi-206	1.3E+07	1.6E+05	7.5E+04	2E+07	**1E+05**
Bi-207	1.8E+07	1.8E+05	2.6E+05	9E+06	**1E+05**
Bi-210	-	-	2.0E+04	9E+05	**1E+04**
Br-82	4.3E+07	4.9E+05	1.0E+05	1E+08	**1E+05**
Cd-107	7.5E+09	1.5E+07	6.8E+06	2E+09	**1E+07**
Cd-109	4.1E+06	7.3E+05	7.2E+06	3E+07	**1E+06**
Cd-113m	-	-	4.2E+04	2E+05	**1E+04**
Cd-115	1.9E+08	1.5E+06	1.4E+04	5E+07	**1E+04**
Cd-115m	1.4E+09	1.8E+07	1.6E+04	5E+06	**1E+04**
Ca-45	8.7E+14	6.6E+10	2.3E+06	2E+07	**1E+06**
Ca-47	4.3E+07	6.5E+05	1.8E+04	2E+07	**1E+04**
C-11	1.1E+10	1.0E+08	1.2E+05	1E+10	**1E+05**
C-14	-	-	-	9E+07	**1E+08**
Ce-139	1.4E+08	8.6E+05	4.9E+07	2E+07	**1E+06**
Ce-141	3.6E+08	5.0E+06	8.5E+05	2E+07	**1E+06**
Ce-144	3.2E+08	1.5E+06	1.3E+05	5E+05	**1E+05**
Cs-134	1.8E+07	1.9E+05	4.6E+05	5E+06	**1E+05**
Cs-134m	3.1E+10	5.9E+07	1.7E+07	5E+09	**1E+07**
Cs-137	4.8E+07	4.3E+05	3.8E+04	5E+06	**1E+04**
Cl-36	1.9E+11	1.9E+08	2.6E+04	7E+06	**1E+04**
Cl-38	4.3E+09	1.5E+08	4.0E+04	1E+09	**1E+04**
Cr-49	5.3E+09	4.7E+07	5.3E+04	2E+09	**1E+05**
Cr-51	1.0E+09	1.2E+06	9.7E+06	5E+08	**1E+06**
Co-56	8.3E+06	1.5E+05	7.8E+04	5E+06	**1E+05**
Co-57	2.4E+08	3.7E+05	3.6E+06	2E+07	**1E+05**
Co-58m	4.4E+13	1.5E+07	1.1E+07	2E+09	**1E+07**
Co-58	3.0E+07	2.6E+05	2.2E+05	2E+07	**1E+05**
Co-60	1.1E+07	2.0E+05	5.4E+05	9E+05	**1E+05**
Cu-60	2.7E+09	4.4E+07	8.2E+04	2E+09	**1E+05**
Cu-64	1.6E+09	8.9E+06	6.6E+04	7E+08	**1E+05**
Cu-67	6.2E+08	3.3E+06	9.2E+04	1E+08	**1E+05**
Dy-159	2.7E+08	1.0E+06	1.0E+07	9E+07	**1E+06**
Er-169	-	3.4E+08	6.2E+05	7E+07	**1E+06**
Er-171	1.3E+09	8.6E+06	2.3E+04	2E+08	**1E+04**
F-18	2.1E+09	1.9E+07	4.7E+04	2E+09	**1E+04**

Table 1 Derived Possession Limits and Exemption Quantities

Radionuclide	MODEL				Exemption Quantity
	Source in Pocket		Beta Dose to Skin of Hands	Internal Dose (Inhalation)*	
	Effective Dose (1 mSv Effective Dose)	Local Skin Dose (Gamma) 50 mSv Skin Dose (40 mg/cm2)	50 mSv Skin Dose (40 mg/cm2)		
	Becquerel	Becquerel	Becquerel	Becquerel	**Becquerel**
Ga-67	4.0E+08	8.0E+05	2.4E+06	2E+08	**1E+06**
Ga-68	3.7E+09	3.4E+07	3.6E+04	1E+09	**1E+04**
Gd-153	1.5E+08	5.0E+05	4.6E+04	1.2E+07	**1E+04**
Ge-68	3.0E+07	2.0E+05	1.6E+04	2E+06	**1E+04**
Au-195	1.6E+08	4.9E+05	4.8E+06	1E+07	**1E+05**
Au-198	1.7E+08	1.5E+06	2.2E+04	5E+07	**1E+04**
H-3	-	-	-	2E+09	**1E+09**
In-111	1.5E+08	8.9E+05	2.4E+05	2E+08	**1E+05**
In-113m	8.9E+09	6.7E+07	9.0E+04	5E+09	**1E+05**
In115	-	-	5.4E+04	7E+04	**1E+05**
I-123	1.4E+09	7.7E+06	7.7E+06	5E+08	**1E+07**
I-125	2.7E+08	7.1E+05	6.8E+06	5E+06	**1E+06**
I-129	4.6E+08	1.4E+06	1.4E+07	7E+05	**1E+06**
I-131	1.0E+08	8.8E+05	4.2E+04	2E+06	**1E+04**
Ir-192	3.6E+07	3.1E+05	3.3E+04	7E+06	**1E+04**
Fe-52	1.5E+08	1.8E+06	9.8E+03	9E+07	**1E+04**
Fe-55	-	1.0E+06	1.0E+07	7E+07	**1E+06**
Fe-59	2.5E+07	4.0E+05	1.3E+05	1E+07	**1E+05**
Kr-77	3.1E+09	2.5E+07	3.9E+04	3.6E+10	**1E+10**
Kr-85	1.3E+10	1.2E+08	2.8E+04	5.4E+10	**1E+11**
Kr-87	3.9E+09	7.3E+07	2.6E+04	1.4E+10	**1E+10**
Pb-210	2.5E+09	1.5E+06	1.9E+04	2E+04	**1E+04**
Mg-28	6.0E+07	1.2E+06	1.1E+04	2E+07	**1E+04**
Mn-52	1.3E+07	1.8E+05	9.2E+04	2E+07	**1E+05**
Mn-54	3.4E+07	3.6E+05	3.5E+06	2E+07	**1E+05**
Hg-203	1.2E+08	8.7E+05	1.0E+05	2E+07	**1E+05**
Mo-99	2.4E+08	1.8E+06	2.1E+04	5E+07	**1E+04**
Ni-59	-	-	-	7E+07	**1E+08**
Ni-63	-	-	-	2E+07	**1E+07**
Ni-65	2.9E+09	5.3E+07	2.7E+04	5E+08	**1E+04**
Nb-95	4.0E+07	3.9E+05	-	2.3E+07	**1E+05**
N-13	2.3E+10	2.1E+08	3.4E+05	8.5E+10	**1E+05**
O-15	1.1E+11	1.0E+09	1.5E+06	2.1E+11	**1E+06**
P-32	-	-	1.6E+04	1E+07	**1E+04**
P-33	-	-	2.4E+06	7E+07	**1E+06**
Po-210	3.4E+12	3.4E+10	1.6E+11	2E+04	**1E+04**
K-42	1.2E+09	2.8E+07	1.3E+04	1E+08	**1E+04**
Pm-147	5.0E+12	2.6E+10	5.7E+06	5E+06	**1E+07**
Ra-226	1.6E+07	2.0E+05	6.4E+03	2E+04	**1E+04**
Rb-86	3.5E+08	4.9E+06	2.7E+04	2.3E+07	**1E+04**
Sm-153	-	-	2.0E+04	6.9E+07	**1E+04**
Sc-46	1.5E+07	1.9E+05	3.2E+05	6.9E+06	**1E+05**
Sc-47	5.5E+08	3.9E+06	6.2E+04	7E+07	**1E+05**
Se-75	7.2E+07	2.9E+05	1.2E+06	2E+07	**1E+05**
Se-79	-	-	-	2E+07	**1E+07**
Na-22	1.3E+07	1.7E+05	3.6E+04	2E+07	**1E+04**

Table 1 Derived Possession Limits and Exemption Quantities

Radionuclide	MODEL				Exemption Quantity
	Source in Pocket		Beta Dose to Skin of Hands	Internal Dose (Inhalation)*	
	Effective Dose (1 mSv Effective Dose)	Local Skin Dose (Gamma) 50 mSv Skin Dose (40 mg/cm2)	50 mSv Skin Dose (40 mg/cm2)		
	Becquerel	Becquerel	Becquerel	Becquerel	**Becquerel**
Na-24	6.4E+07	2.3E+06	1.8E+04	1E+08	**1E+04**
Sr-85	5.6E+07	3.2E+05	1.7E+06	2E+07	**1E+05**
Sr-87m	4.4E+09	3.3E+07	1.5E+05	5E+09	**1E+05**
Sr-89	3.6E+11	4.0E+09	1.6E+04	5E+06	**1E+04**
Sr-90	5.4E+12	4.9E+09	1.0E+04	1E+05	**1E+04**
S-35	-	-	-	7E+07	**1E+08**
Tc-99	-	-	6.2E+05	1.8E+07	**1E+06**
Tc-99m	5.1E+09	3.2E+07	1.6E+07	5E+09	**1E+07**
Tl-201	3.4E+08	1.3E+06	4.1E+06	9E+08	**1E+06**
Tl-204	-	-	3.0E+04	9E+07	**1E+04**
Th-232	1.1E+07	1.4E+05	8.5E+03	2E+02	**1E+02**
Th-234	1.3E+09	4.2E+06	2.6E+04	4.6E+06	**1E+04**
Sn-113	9.0E+07	4.0E+05	1.0E+05	2.0E+07	**1E+05**
Dispersible uranium compounds:					
U-234	5.4E+09	4.8E+06	4.8E+07	5E+03	**5E+03**
U-235	1.3E+08	3.5E+05	8.1E+05	5E+03	**5E+03**
U-238	1.1E+09	2.3E+06	1.5E+04	5E+03	**5E+03**
Non-dispersible uranium compounds:					
U-234	-	-	6.2E+06	-	**6E+06**
U-235	-	-	6.2E+06	-	**6E+06**
U-238	-	-	6.2E+06	-	**6E+06**
Xe-123	2.6E+09	2.5E+07	1.1E+05	1.1E+11	**1E+11**
Xe-129m	3.4E+08	1.0E+06	6.1E+04	1.1E+11	**1E+11**
Xe-133	6.1E+08	3.5E+06	5.9E+05	2.5E+11	**1E+11**
Xe-135	1.7E+09	1.3E+07	2.4E+04	4.6E+10	**1E+10**
Y-90	1.3E+13	9.5E+09	2.6E+04	1.6E+07	**1E+04**
Zn-65	5.0E+07	7.2E+05	3.3E+06	9E+06	**1E+06**
Zr-95	2.0E+07	1.9E+05	2.1E+05	7E+06	**1E+05**

* Note: Noble gase DPLs are based on Model 4, skin dose